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Tha Development of Marine Corps Tracked Landing Vehicles

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ABSTRACT

It is very doubtful whether the amphibious landings by the U.S. Armed Forces on the Japanese held islands in the Pacific during World War II would have been successful without the massive deployment of tracked landing vehicles. The LVT1 (Landing Vehicle Tracked) chosen by the Marine Corps in 1941 for War production, was patterned after Donald Roebling's successful Alligator, conceived for rescue operations during hurricane flooding in Florida. This paper describes the development of this peaceful rescue craft and its transformation into a military vehicle which was used extensively in World War II.

INTRODUCTION

During World War II the United States worked its way across the Pacific in a stepping stone fashion by capturing Japanese held islands. These islands were then used as either air or naval bases in support of continuing assault operations. The primary method of securing occupied territory was by a direct attack on the enemy fortified shoreline. After an initial period of air and off-shore naval bombardment U.S. Marine Corps and Army ground troops were brought ashore in an amphibious landing.

Specialized types of landing craft and vehicles were developed to meet the needs of amphibious battle. One type of landing vehicle was the LVT (Landing Vehicle Tracked) or amphibious tractor. Originally designed for hurricane rescue, it was first used logistically at Guadalcanal in 1942 for transporting supplies from transport ships to the beach-head. However soon after their introduction LVT's were modified by the addition of armor and armament so that they could be used tactically in amphibious combat.

AMPHIBIOUS LANDINGS IN HISTORY

Amphibious landings are not unique to modern warfare. During the Peloponnesian Wars (415-429 B.C.) Athenian warships carried troops to the shores of Persia. These fast moving triremes, carrying more than 200 men, were deliberately run aground by the steersman. Gangways were lowered to allow debarkation of the troops aboard.

Centuries later, leaders of the Roman Empire often had to consider the logistics of ship to shore landings in their battle plans. Scipio Africanus defeated Carthage by sending soldiers from Spain to the African coast. Julius Caesar utilized amphibious warfare in his conquests of Britain, Spain, Africa, Egypt and the Balkan peninsula. Dring one battle in the invasion of Britain (55 B.C.), a planned amphibious assault turned into an unmitigated disaster. Overzealous troops jumped from landing vessels before they reached shallow water and were thus forced to swim to shore. Unfortunately the Britons had trained their horses to ride directly into the surf and they quickly cut down the exhausted and floundering Roman soldiers. Undaunted by this setback Caesar withdrew and regrouped, successfully invading later that year (Ref.8).

During the Crusades, Genoa shipyards were contracted to build special transport and landing vessels for use by St.Louis during his crusade to Egypt in 1249. These ships were equipped with gangplanks and drawbridges to facilitate embarkation and debarkation. Another type of boat, known as a taridae, a cross between a sailing ship and a galley, was built to transport the smaller ships used for landings as well as having stable areas for horses (Ref.8).

With the advent of the industrial revolution and the development of steam engines, troops and supplies could be

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transported over much longer distances in shorter amounts of time. Steam powered vessels were first used for an amphibious landing by American troops at Vera Cruz, Mexico in 1849. A correspondent at the scene remarked, "The whole American Army reached the shore in fine style without accident or loss"(Ref. 8).

However naval vessels became larger and more sophisticated as time went on. Large ships were dependent on the availability of harbors with docks and cranes in order to load and unload supplies. The increasing expenditures required for the construction and maintenance of navy vessels made naval commanders reluctant to undertake operations which would put them within the range of shore batteries. This factor contributed to a growing rivalry among the various branches of the armed services for money, men and equipment, which was often manifested by poor communication, if not outright uncooperation. This unfortunate state of affairs is most vividly exemplified by examining the events surrounding the disastrous amphibious landing operation which took place on the Gallipoli peninsula in Turkey during World War I.

The Battle of Gallipoli

The intent of the Gallipoli operation was to wrest control of the Dardanelles from the Turks so that British ships would have free passage to attack Constantinople. The original plan for the attack was to have a large naval force shell the forts which guarded the entrance to the straits. Once the forts had surrendered, British Marine demolition units were to be landed and the forts destroyed. Though the British Admiralty did not particularly care for "ships fighting forts" they felt the plan was feasible. However three days before the scheduled start of the attack the Minister of War caved in to pressure from diplomats to land large numbers of ground troops in addition to the marine units. The diplomats hoped that a large show of force would persuade Italy and the Balkan states to join the Allied camp.

The naval bombardment began as planned on February 19, 1915, but troops did not arrive to a staging area in Alexandria, Egypt, until mid-April. Most of them had been pulled from duty on the Western front and had never participated in an amphibious assault. The supply ships which had arrived from England were incorrectly loaded and had to be completely emptied and re-packed before being able to steam to Turkey. Finally an attack was planned for the pre-dawn hours of April 24th. A convoy of two hundred large ships and hundreds of small boats made their way to Gallipoli.

The Turkish army by this time had been reinforced by the arrival of German troops; even so the coastal areas chosen for landing were not heavily fortified. Of the five landing sites only one, an area directly south of the Cape of Halles, presented considerable difficulty. There, in addition to Turkish machine gun emplacements in the hills overlooking the beach, wire entanglements had been submerged below the water's surface about fifty yards from shore. Most of the boats became stuck in the wire, unable to off-load and vulnerable to attack. One ship managed to avoid the wire but in the process ran aground. Desperate to unload her more than 2000 troops the captain ordered a makeshift bridge constructed between the ship and the shore made of small boats connected by gangplanks. Very few of the soldiers made it to the beach-head. This event proved to be a foreshadowing of the myriad disasters which would unfold opver the next several days.

Landed troops soon found themselves without adequate supplies of ammunition, food or water. On those beaches which had met minimal resistance, commanders did not even come ashore and no attempt was made to push inland. By the time supply lines were re-established and all forces landed, the enemy had arrived in numbers and the hills were "bristling with rifles". The battle soon deteriorated into the trench type war being waged in Europe, with Allied forces advancing only a few hundred yards inland. By May 5th, ninteen thousand lives had been lost. Though reinforcements were sent to Gallipoli for an August 9th attempt to straddle the peninsula, the offensive was a failure. Finally in December an evacuation was ordered as troops were need to fight the German invasion of Serbia. Though over a quarter of a million men died during the seven month siege of Gallipoli, not a single life was lost during the evacuation.

The experiences of the Allied forces at Gallilopi highlight an important fact. The amphibious landing in itself, that is the obtaining of a foothold on an occupied shore, is not the most difficult nor decisive aspect of the total assault. Rather the difficulty arises hours or even days later when the enemy must be encountered and conquered on his own territory. Consequently, planning and more importantly initiative, must not stop when troops secure the beach-head. Commanders must utilize the impetus of this landing to propel troops inland as soon as possible. To do this effectively there must be a method of providing continuous access to supplies, ammunition and additional troops.

Unfortunately the lesson of Gallipoli was lost on many military men during the years between World Wars I and II. In their eyes the massive number of casualties inflicted at Gallipoli was taken as an absolute indictement of the technical feasibility of amphibious landings. They neglected to analyze the post-landing strategies which were, in reality, the cause of those casualties. It was largely on this misguided conviction that Douglas MacArthur based his 1936 plan for the defense of the Philippines. He wrote that he was vehemently against the operational employment of large-scale amphibious landings because (referring to the battle of Gallipoli), "in many cases (Turkish infantry) decimated whole divisions in their attempts to land"(Ref.8).

However there were elements in both the U.S. Navy and Marine Corps who did not as

readily dismiss the possibility that amphibious landings were a workable and effective wartime strategy. After the establishment of the Fleet Marine Force in 1933, the Marines practiced and perfected various attack scenarios involving amphibious landings. At the same time they began looking for innovative types of equipment, vehicles and landing craft which could be used to effectively transport both troops and supplies.

Despite the advances made in the mechanics of warfare during World War I there had been little development of specialized landing craft. Consequently when a magazine article appeared in 1939 describing the invention of an amphibious tractor by a Florida man named Donald Roebling, there was a stirring of interest among military planners. The tractor, nicknamed " Alligator", was designed for hurricane rescue, but it met the military's requirement for amphibious vehicles; its mode of propulsion was "the same in water as it is on land". Alerted to the article by the Commandant of the Marine Corps, the Marine Corps Equipment Board began an investigative study to determine if the Alligator could be utilized during an amphibious assault to move supplies from off-shore support ships to inland battle lines.

ROEBLING'S ALLIGATOR

In the spring of 1932, a devastating hurricane swept across the southeastern United States. Left in its wake was massive destruction and scores of fatalities. Many of the deaths occurred because conventional means of personnel evacuation, either on foot or by truck or boat were unsuited to many areas of the Florida wetlands, especially in the Everglades. As a result of this tragedy Donald Roebling, a Clearwater, Florida millionaire, inventor and engineering enthusiast, decided to investigate the possibility of constructing a tractor-like vehicle which would be as equally at home in water as it was on land. Utilizing his considerable personal wealth, Roebling, grandson of Brooklyn Bridge builder Washington A. Roebling, set up a production facility on the grounds of his large estate and in 1933 began to build his dream.

Roebling was not the first to explore the concept of an amphibious vehicle. As early as 1918 British tanks were being outfitted with pontoons to facilitate in water travel. In 1930 two truly amphibious tanks, designed specifically for both water and land use, were built in England by Vickers-Carden-Lloyd. However these tanks relied on a complex propeller assembly for propulsion which was extremely vulnerable to damage on land from rough terrain and hostile fire (Ref.4). Whether or not Roebling was aware of these designs is unknown. However he approached the propulsion dilemma from a different perspective. Instead of attempting to make his tractor boat-like he chose to enhance the natural propulsion qualities of the tractor's moving treads by affixing paddles to them.

Because buoyancy was an essential factor in the development of an amphibious vehicle Roebling opted to build primarily of lightweight dura-aluminum. However, he and his crew found working with aluminum to be quite difficult. The metal was hard to handle and conventional riveting techniques proved unsatisfactory. They eventually solved these problems by employing woodworking rather than metal-working tools and using flat cone rivets.

The first tractor was completed in 1935. It's drive train and gearing were identical to those of a conventional tractor, however the cab area was enclosed and the body was open, resembling a truck. Christened the "Alligator", Roebling's first prototype model was able to reach land speeds of 25 mph. However the design of its tread paddles, which were placed horizontally across the face of the moving track, considerably slowed its speed in the water. As a result Roebling ordered the vehicle completely disassembled and he went to work on correcting the propulsion problem as well as attempting to cut down on weight in order to improve buoyancy. In April of 1936 the Alligator was rebuilt. The tread paddles were now slightly curved and positioned diagonally across the track improving fluid displacement. To enhance buoyancy balsa wood floats had been added to the outside of the cargo bay. These design changes resulted in a double of the original water speed without significantly reducing land speed. However by this point the amount of work necessary to design, build and modify the Alligator had burgeoned beyond the capabilities of Roebling's modest "backyard" machine shop. He began contracting out the construction of various parts to a local firm, the Food Machinery Corporation of Dunedin, Florida. Soon they were actively involved in the implementation and construction of the design modifications which Roebling was now making at a furious pace (Ref.3).

The Alligator was rebuilt again in September of 1936. This model saw the elimination of the front and rear overhangs which tended to cause hangups as the Alligator climbed up steep, debris strewn stream banks. In 1937 the vehicle was shortened and the idlers removed. Rigid bogie wheels were replaced by chain glides having built in roller bearings riding on a smooth molybdemeum steel channel on the bottom, with rubber matting on the top. With these modifications overall performance improved to the point that maximum water speed was now 9.5 mph, with speeds up to 23.5 mph on land. The Alligator had a total weight of 4 Tons and was powered by a 95 h.p. Mercury engine.

In 1939 Donald Roebling was ready to show his invention to the world (Fig.2). He put the Alligator through its paces for a reporter from Life magazine, who stood in astonishment as, with a loud roar, the Alligator plowed over 8 inch mango trees, climbed 3 foot vertical banks, and splashed

through muddy swamps. The alligator proved to be as seaworthy as it was intimidating; it drew less than three feet of water in its open cargo bay during regular operation, and would not capsize or sink even if the bay was completely filled with water.

The resulting article was that which caught the attention of the Marine Corps. By February of 1941 the Navy had placed an order for two hundred of the amphibious tractors with the more than three million dollar contract going to the Food Machinery Corporation. In a truly patriotic gesture Donald Roebling refused any monetary compensation from the Navy for his invention, desiring only an assurance that the vehicle would be utilized to transport the wounded and he donated the design to the government as his contribution to the war effort (Ref.5).

OPERATIONAL USE AND TECHNICAL DEVELOPMENT OF THE LVT

The LVT was first used operationally as a means of transporting supplies from ship to shore and from shore to interior combat areas prior to the landing of wheeled vehicles. Beginning in 1942 with the Battle of Guadalcanal the logistical value of LVT's in amphibious assault operations exceeded expectations. In fact field commanders were reluctant to beach LVT's once trucks and jeeps arrived on shore and often ordered the LVT's to provide continuous shuttle service between the supply dumps and the battle line.

The role of the LVT became tactical as United States forces moved into the Central Pacific. Here coral reefs often kept ships and small craft away from shore, but due to their amphibious nature the LVT's were able to land. During the course of the battle for the capture of Peleliu on September 15,1944, LVT's performed in a variety of tactical capacities. Howitzer armed amphibious tractors led the first wave of the attack followed closely by LVT's acting as troop transports. There were three LVT's equipped with Navy Mark I flame throwers capable of launching a stream of ignited fuel over 100 yards (Ref.3).

Since the LVT's were able to accurately gauge the depth of the water they were utilized to guide tank units to shore thereby preventing the tanks from becoming swamped. They also led tanks around boulders, potholes and bomb craters. These LVT's were loaded with fuel, ammunition and maintenance supplies, giving the tank units access to a mobile supply dump upon landing. Due to this LVT support twenty seven tanks were able to land at Peleliu within ten minutes despite heavy shelling by the enemy. Once troops had been landed some LVT's were utilized as ambulances and command and communications centers, while the remainder patrolled the northern aspect of the reef to deter Japanese counter-landings.

Throughout World War II LVT's could be found working as recovery vehicles, shallow water minesweepers, mobile repair shops, command vehicles, wire and carpet layers and rocket projectors. At Tinian in the Marianas, LVT's were equipped with special portable ramps which allowed them to climb the coral cliffs surrounding the island. In all LVT's were used in thirty-eight major operations during World War II including four operations in the European theater. During the Korean war LVT's were utilized extensively during the landing at Inchon (Ref.3).

Because the LVT was used so frequently during World War II it was inevitable that design changes would be initiated and new models be developed as the war progressed and the LVT was incorporated into amphibious assault strategy. As previously noted, the Marine Corps' first tracked landing vehicle, LVT1, was put into production in February of 1941. The first amphibious tractors rolled off the FMC production line in July, 1941 and by August, 1941 the first Marine Corps Amphibious Tractor Battalions had been formed (Ref.2).

To more clearly meet the needs of the Corps the design of the Alligator was somewhat modified. These design modifications included fabrication from mild steel instead of aluminum and an engine upgrade to a 120 h.p. Lincoln. Eventually a total of 1225 LVT1's were built. Almost immediately after awarding the contract to FMC for the initial production of the LVT1, the Marine Corps Production Board began working on a design for an armored LVT. Simultaneously the Navy contracted Borg-Warner Corporation to begin a similar investigation (Ref.3). (Borg-Warner had originally become involved in LVT production when their Morse Chain Company division was asked to improve the track-laying mechanism of the LVT1.) The result of their investigation was the LVT(A)1. The LVT(A)1 was equipped with steel plate armor and armed with a 37mm gun in a M3 Light Tank turret. It had a 250 h.p. Continental engine, hydramatic transmission and rigid bogie wheels. The development of the LVT(A)1 was an attempt by the Marine Corps to produce a heavy weapon which could bridge the gap in fire power that arose when air and naval bombardment was suspended while troops were being landed.

After the LVT1 had been fully integrated into combat operations it became clear that further design improvements would have to be made. With several months of continuous use problems had surfaced in both the track and suspension systems. The tracks were easily thrown and the roller bearings corroded rapidly in salt water. The rigid suspension caused maneuvering problems and damage to cargo.

Consequently the LVT2, or Water Buffalo was introduced in 1942 (Fig.3). The tracking system was improved by changing both the shape and attachment mechanism of the paddle grousers. Roebling's design for the Alligator employed curved grousers mounted diagonally across the track, however after testing more than forty-seven different shapes, a W-shaped grouser face was decided upon. The grousers were made of cast aluminum, 2.75 inches high and were bolted

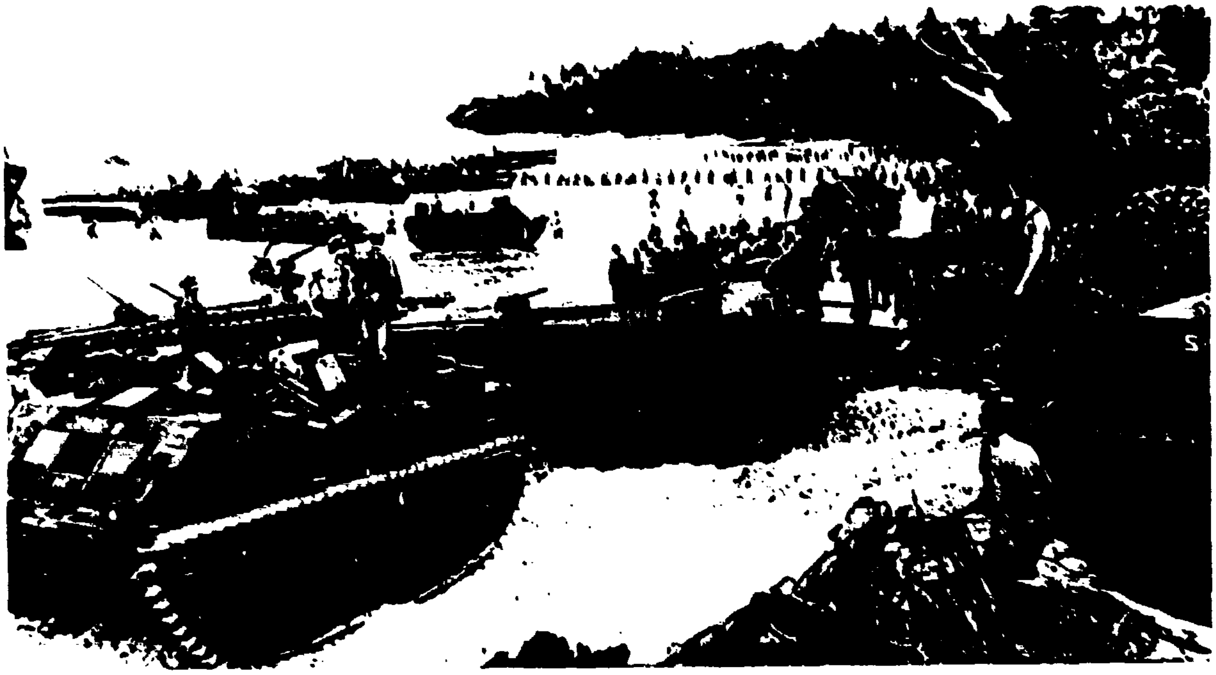

Figure 1. An LVT1 Alligator (left) and an LVT2 Water Buffalo (right) on the beach ·t Emirou; March 20, 1944.

to the track; a practical necessity as they wore out rapidly when run on land or over coral reefs.

The suspension was changed to a torsilastic, or rubber torsion type. It consisted of a hollow inner shaft which was anchored to the hul?. A large diameter hollow shaft fit over the inner shaft with rubber vulcanized between the two. The outer shaft had wheel arms between which the bogie wheel arms were mounted. As the LVT2 moved over irregular terrain the outer shaft twisted on the inner shaft with the rubber acting as a spring. The overall effect was that of a solid torsion bar. Additionally the hull shape was streamlined and M3 Light Tank Turrets and Continental engines and final drives were installed. These components were chosen for installation because they were readily available stateside with spare parts that could be obtained in the field. The LVT2 also had bolt on armor so it could be utilized as a troop transport. A fully armored version, the LVT(A)2 was placed in production the same year and was intended for use by the Army as a cargo carrier. It was the only cargo carrier to ever receive the "A" designation.

In 1945 another cargo transport was introduced. This model was known as the Bushmaster and designated as LVT3 (Fig.4). It was the prototype for all standard post war models. The major design change in the LVT3 was the addition of a winch-lowered rear ramp to facilitate loading and off-loading (previous models were loaded over the side). The engine, transmission, bilge pump and blower were moved into the pontoons welded to either side of the hull. This change significantly increased available cargo space. Also the track design of the LVT3 was quite different from that of earlier models. Rather than having dry pin type bushings, which tended to quickly wear out, the LVT3 used rubber bushings which lasted considerably longer. Additionally the number of track plates per side was increased from 73 to 103, their width reduced from 14.25 to 12.5 inches and the pitch increased by one inch (Ref.3). However in spite of its narrower tracks the LVT3 traveled as well or even better than other models of LVT.

Additional models of LVT were developed as the war progressed. The LVT4 was the LVT2 with its engine moved forward and a stern ramp added (Fig.5). This change increased the number of troops which could be carried from 18 to 30. Like the LVT2 and 3 it had bolt on armor. The fully armored LVT(A)4 was identical to the LVT(A)1 except its turret was changed to that of a M8 Howitzer Carriage with a 75 mm Howitzer gun. The LVT(A)5 was essentially the same as the LVT(A)4, however the M8 Howitzer carriage was stabilized and a power turret traverse was added.

Post World War II modifications to the LVT3 included the addition of an armored cover over the cargo compartment to protect passengers and a small machine gun turret. The LVT(A)5 was modernized by installing a cover for its turret and a rounded false bow which increased buoyancy and produced better in-water performance. Both these models were used during the Korean War. The LVT(P)-5A1 was introduced in 1955. It had a greater cargo capacity than the LVT(A)5, being able to carry 34 troops or 6 tons of cargo.

In 1963 the Marine Corps issued specific operational requirements for the

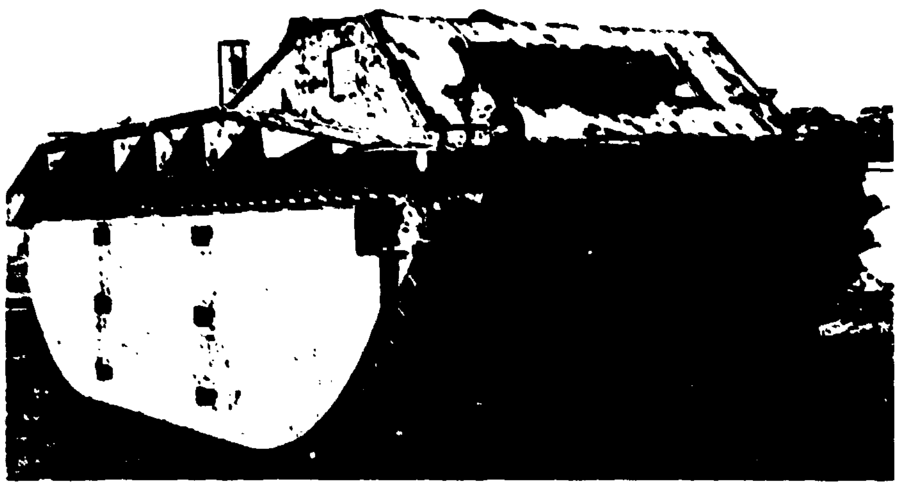

Figure 2. LVT1 Prototype with Roebling's curved grouser design.

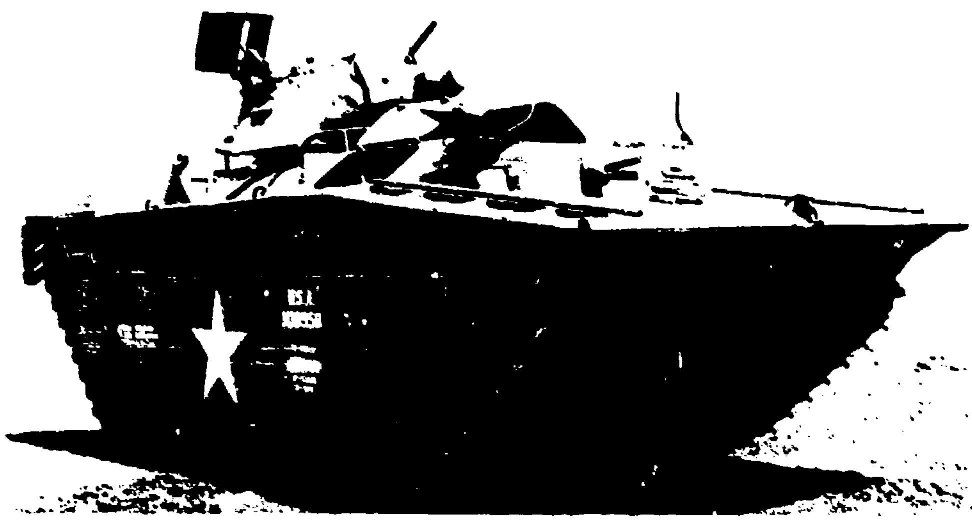

Figure 3. An LVT2 Water Buffalo; note the W-shaped grousers.

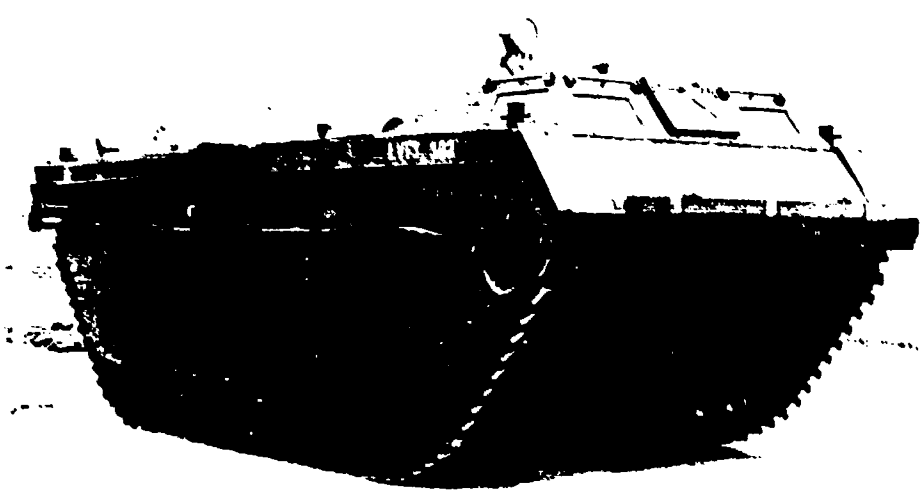

Figure 4. The LVT3 Bushmaster with bolt-on armor installed over the bow and pontoon sides.

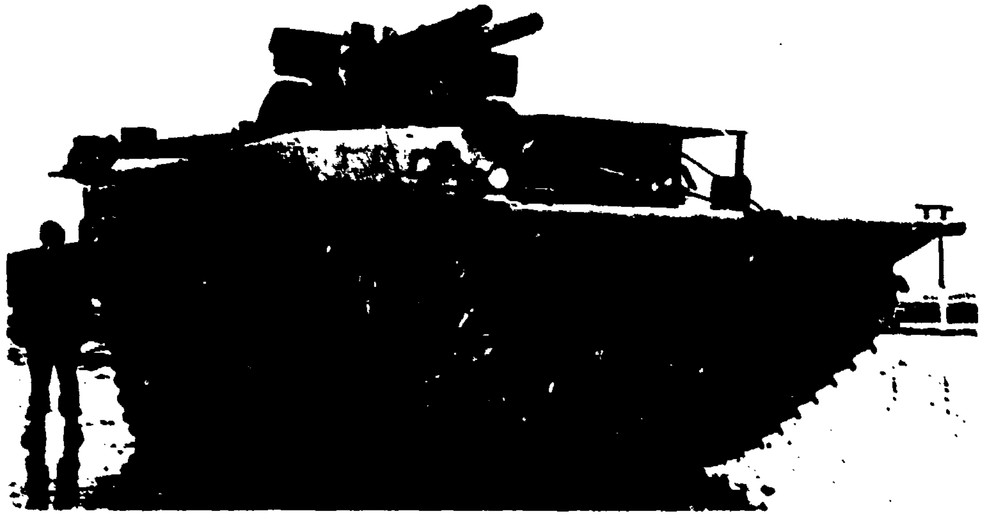

Figure 5. An LVT4 carrying a 150mm Howitzer with standard field carriage.

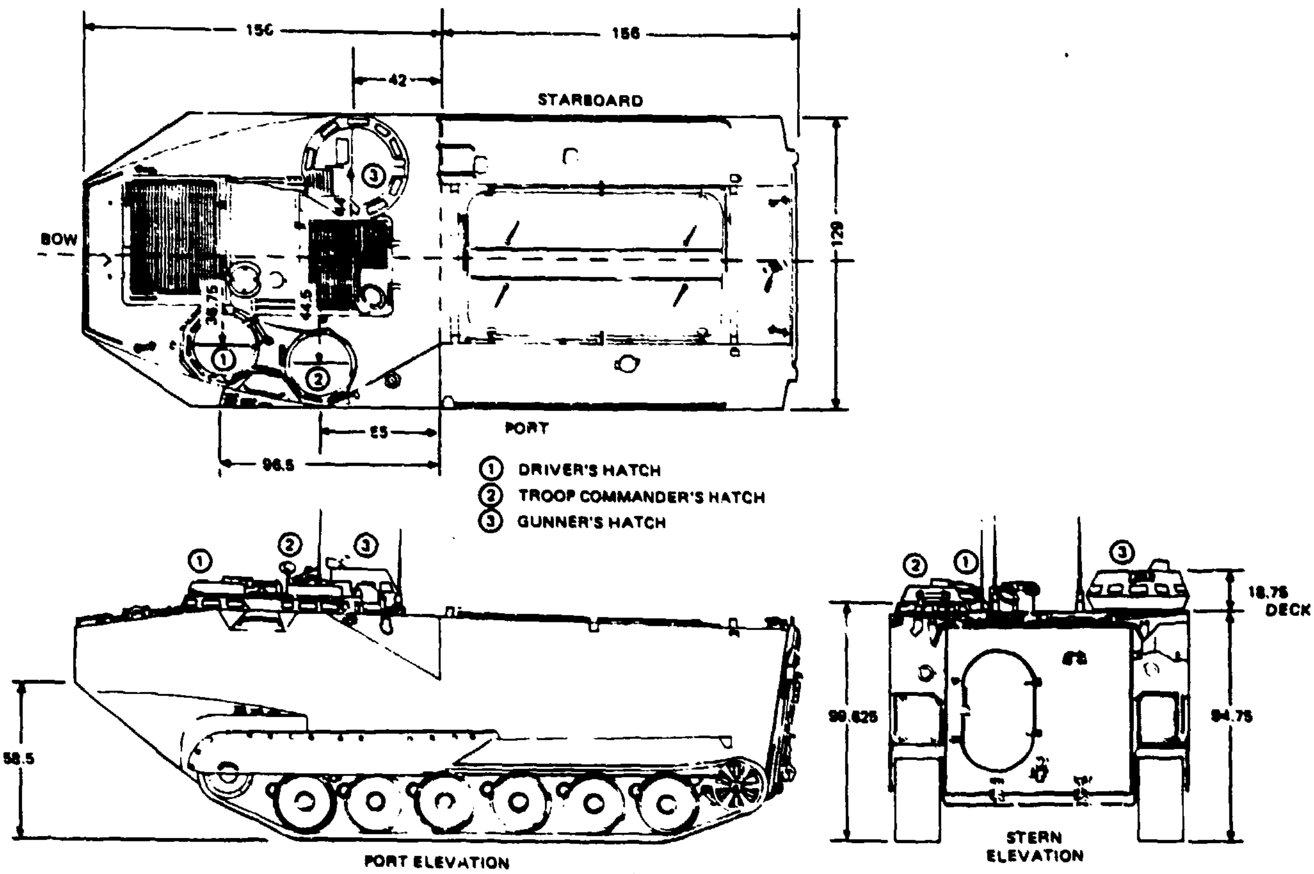

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Figure 6. Drawing of LVTP-7, showing location of hatches.

development of new amphibious vehicles (Ref.7). As a result the LVT(P)7 was introduced in 1971 (Fig.6). This model is the one currently used by the U.S.Marine Corps. The LVT(P)7 differs from its World War II predecessors in that it has a diesel rather than a gasoline engine. This change has increased its land operating range to almost 300 miles. It is also considerably lighter, weighing only 25 tons fully loaded versus 43 tons for the LVT(A)5 due to the replacement of steel armor with aluminum and a smaller overall size. Armament on the LVT(P)7 consists of the caliber .50 M85 weapons system mounted in a 360-degree electro-hydraulically powered turret (Ref.9).

FUTURE OF THE LVT

Though the LVT played a major role in the victory of U.S. forces in the Pacific and contributed to the successful liberation of Inchon during the Korean War, it was not utilized extensively in a tactical capacity during the Vietnam Conflict. Most of the amphibious operations conducted by the Marine Corps in Vietnam, the largest of which was at Chu Lai in 1965, most often delegated to transport helicopters the task of moving troops to and from the beach-head.

Whether or not the LVT will continue to play a role in modern warfare depends to a great extent on the viability of the amphibious assault as a technologically feasible military operation. There are several factors which may constrain the Marine Corps from fully exploiting its amphibious warfare capabilities. Foremost among these has been the advent of precision-guided munitions.

The Marines must depend upon amphibious landing craft and/or helicopters for transport during the assault phase of an amphibious landing. Obviously these vehicles will be very exposed to hostile fire which, with modern technology, tends to be quite accurate and most often deadly. Moreover the logistics of a full-scale amphibious assault operation dictate the presence of a large naval force offshore thereby presenting a ready target for weapons, "whose probability of making a direct hit upon a tank, ship, radar, bridge or airplane (depending on its type) is more than a half" (Ref.1). The large distance from shore required to move ships out of target range means that if LVT's were to be deployed they would be forced to steam for several hours over open water prior to landing, severely depleting fuel reserves and making them vulnerable to attack. Because of the relative low cost, simplicity and availability of these weapons they will most certainly be utilized by the enemy in future conflicts.

Additionally current emphasis on the creation of a rapid deployment force precludes the utilization of full-scale amphibious assaults. At present it takes a minimum of forty-five days to assemble, load and transport to the landing area a Marine Amphibious Force (the largest of the operational amphibious units). These factors, as well as the fact that there is already a sizeable contingent of U.S. forces overseas, suggest that the Marine Corps may be entering a new era in which its mission need no longer focus exclusively on the executuion of amphibious assaults.

Since the LVT remains a vital part of today's Marine Corps' arsenal, future modifications must enhance its ability to meet the challenge of both amphibious and non-amphibious battle. The design characteristics of the LVT's currently used by the Marine Corps emphasize tactical deployment on land (higher speeds, longer operating range, increased armor, etc.) as well as amphibious utilization, reflecting the diverse situations in which it might be employed. Consequently it seems that the current generation of LVT's has the potential to evolve into a rugged, all-terrain, long range transport vehicle which still retains the characteristics unique to its amphibious predecessors.

APPENDIX

Metric Conversion Factors
- 1 inch = 2.54 cm
- 1 foot = 30.48 cm
- 1 mile = 1.609 km
- 1 h.p. = 1 h.p.(metric)

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